APPLICATION UNDER UNITED STATES PATENT LAWS

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Invention: OPTICAL DISK APPARATUS AND WAITING METHOD THEREOF

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<u>This is a:</u>

☐ Provisional Application

☒ Regular Utility Application

☐ Continuing Application
  ☐ The contents of the parent are incorporated
  by reference

☐ PCT National Phase Application

☐ Design Application

☐ Reissue Application

☐ Plant Application

☐ Substitute Specification
<u>Sub. Spec</u> Filed _____
    in App. No. ____ / _____

☐ <u>Marked up Specification re</u>
Sub. Spec. filed _____
    In App. No ____ / _____

SPECIFICATION

TITLE OF THE INVENTION

OPTICAL DISK APPARATUS AND WAITING METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the

5   benefit of priority from the prior Japanese Patent

Application No. 2002-190892, filed June 28, 2002, the

entire contents of which are incorporated herein by

reference.

BACKGROUND OF THE INVENTION

10   1. Field of the Invention

The present invention relates to an optical disk

apparatus causing an optical head to wait before an

unrecorded region after recording and reproducing

processing of an optical disk, and a waiting method

15   thereof.

2. Description of the Related Art

Recently, an optical disk apparatus such as DVD

(Digital Versatile Disc) has been developed and comes

widespread. Further added value such as operating

20   reliability and usability is required for the optical

disk drive. For example, in an optical disk apparatus

described in Jpn. Pat. Appln. KOKAI Publication

No. 10-79126, the optical disk apparatus decides

whether an optical disk is OTP or PTP in reproducing

25   the optical disk in which plural information recording

layers exist on one side, the optical disk apparatus

waits by one-track jump to an inner or outer radius of

the optical disk when the optical disk apparatus received temporally stop command.

The above-described optical disk apparatus disclosed in the publication performs the limited processing to a reproduce-only optical disk, and can hold a relatively stable servo state by the one-track jump.

However, in a recordable type of optical disk, because a recorded region differs from an unrecorded region in reflectivity of a recording layer, holding a servo state at a boundary between the recorded region and the unrecorded region is to perform the servo at a region where a servo signal level fluctuates, so that it is an extremely unstable state. When the recording is started from the boundary region, in order to properly generate necessary information such as error correction code, it is necessary to return to the truck before two tracks at the maximum to reproduce the information and then the recording is performed.

That is, the above-described conventional optical disk apparatus is reproduce-only, and can not solve specific problems of the optical disk recording apparatus. This is because the unrecorded region and the recorded region in the information recording layer are different in the reflectivity depending on characteristics of the optical disk. With reference to the characteristics of the optical disk, there are two

kinds of characteristics, i.e., low-to-high charac-
teristics in which the reflectivity is increased by the
data recording and high-to-low characteristics in which
the reflectivity is decreased by the recording. This
5   change in the reflectivity is generally double or
triple or more, various kinds of signals are affected
by the change in the reflectivity in the boundary
region between the recorded region and the unrecorded
region.

10   As a result, it is difficult to perform the
precise servo in the boundary region between the
recorded region and the unrecorded region, like the
conventional optical disk apparatus, possibility arises
that the optical disk apparatus is positioned at both
15   regions of the recorded region and the unrecorded
region in a track holding state of the waiting, when
the optical disk apparatus waits at the position before
one track from a reproducing end region. Accordingly,
particularly in the case of the recording processing,
20   there is the problem that the servo operation can not
be stably maintained during the waiting for the next
command.

      Further, in order to perform the recording and
reproducing the information, rapid response time from
25   generation of recording and reproducing request to
start of the recording and reproducing processing is
required in the case of the recording type of optical

disk. However, there is the problem in the conven-
tional apparatus that the recording processing can not
be immediately performed even if the apparatus receives
a record command, because the optical head does not

5   always wait in the unrecorded region.

In the case of the recording processing, sometimes
generation is performed after reading the error
correction code embedded in the previously recorded
data. In order to smoothly realize this operation, it

10   is an optimum method in which the optical head waits at
a position where the error correction code to be read
is recorded. There is the problem that the rapidly
reading of the error correction code is not necessarily
performed only by the return of one track like the

15   conventional method.

BRIEF SUMMARY OF THE INVENTION

According to an aspect of the present invention,
there is provided an optical disk apparatus comprising:
an optical head which irradiates an optical disk having

20   an information recording layer with a laser beam or
receives reflected wave, and performs recording
processing or reproducing processing; a waiting
position decision portion which detects physical
properties of each region in the optical disk after the

25   recording processing or reproducing processing is
finished, and decides a waiting position of the optical
head according to the physical properties; and a

control portion which controls a position of the
optical head according to the waiting position decided
by the waiting position decision portion in order to
move the optical head to wait.

5   BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a block diagram showing an example of an
optical disk apparatus according to a first embodiment
of the invention;

FIG. 2 is a block diagram showing an example of an
10   optical disk according to the first embodiment of the
invention;

FIG. 3 is a view showing a configuration of an
arrangement of an optical head and the like in the
optical disk apparatus according to the first
15   embodiment of the invention;

FIG. 4 is a diagram showing a configuration of the
optical head in the optical disk apparatus according to
the first embodiment of the invention;

FIG. 5 shows an example of a waiting position of
20   the optical head in the optical disk apparatus
according to the first embodiment of the invention;

FIG. 6 shows another example of the waiting
position of the optical head in the optical disk
apparatus according to the first embodiment of the
25   invention;

FIG. 7 shows another example of the waiting
position of the optical head in the optical disk

apparatus according to the first embodiment of the invention;

FIG. 8 shows another example of the waiting position of the optical head in the optical disk apparatus according to the first embodiment of the invention;

FIG. 9 shows another example showing the waiting position of the optical head in the optical disk apparatus according to the first embodiment of the invention;

FIG. 10 is a flow chart for explaining an example of a waiting method according to the first embodiment of the invention;

FIG. 11 is a flow chart for explaining waiting processing of the optical head including a layer jump of the optical disk apparatus according to the first embodiment of the invention;

FIG. 12 shows an example of a waiting position of an optical head in an optical disk apparatus according to a second embodiment of the invention;

FIG. 13 shows an example of a waiting position of an optical head in an optical disk apparatus according to a third embodiment of the invention;

FIG. 14 is a flow chart for explaining an example of a waiting method according to the third embodiment of the invention;

FIG. 15 is a flow chart for explaining an example

of the waiting method according to the third embodiment
of the invention;

FIG. 16 is a block diagram showing an example of
the optical disk apparatus according to the third
embodiment of the invention;

FIG. 17 is a flow chart for explaining waiting
processing of the optical head including a layer jump
of the optical disk apparatus according to the first
embodiment of the invention; and

FIG. 18 is an explanatory diagram showing a case
in which a waiting position and a boundary track belong
to different zones, respectively.

DETAILED DESCRIPTION OF THE INVENTION

An optical disk apparatus and a waiting method
thereof according to an embodiment of the invention
will be described in detail below, referring to the
accompanying drawings.
[Optical disk apparatus according to an embodiment of
the invention]

A configuration of an optical disk apparatus
according to a first embodiment of the invention will
be described. FIG. 1 is a block diagram showing an
example of the optical disk apparatus according to the
first embodiment of the invention, FIG. 2 is a block
diagram showing an example of an optical disk according
to the first embodiment of the invention, FIG. 3 is a
view showing a configuration of an arrangement of an

optical head and the like in the optical disk
apparatus, and FIG. 4 is a diagram showing a
configuration of the optical head in the optical disk
apparatus. There will be described the optical disk
apparatus performing the recording processing to the
optical disk in which, as shown in FIG. 2, two
information recording layers are provided on an one
side and an information track of each information
recording layer has a single-spiral-shaped groove
structure 101 continuously recordable from an inner
radius to an outer radius.

As shown in FIG. 2, an optical disk D which is an
object of the processing by the optical disk apparatus
according to the first embodiment of the invention is
a rewritable type of medium having a phase change
recording layer as the information recording layer, and
is the recording medium having a first recording layer
3 and a second recording layer 4, in which the
recording and reproducing of the information are
performed by a light beam condensed by an objective
lens 5 provided in the optical disk apparatus according
to the first embodiment of the invention. Rotation of
the optical disk D is controlled by a spindle motor
rotating control circuit 29, which detects the number
of revolution by output of an encoder 28 installed in a
spindle motor 2 provided in the optical disk apparatus
or a reproducing signal from the optical disk D and

makes the number of revolution at the desired number. Particular when information is recorded, a ZCLV (Zoned Constant Linear Velocity) method maintaining constant linear speed of the rotation or the like is adopted.

5 In the zone to which the track where the recording is performed belongs, the rotation is controlled so as to be at the constant number of revolution.

An optical head 10 perform the recording (forming a mark) by irradiating a predetermined information

10 recording layer of the optical disk with a laser beam having a predetermined wavelength. The recording is performed by, for example, a mark length recording method in which an edge of the recording mark has the information. The laser beam emitted from a laser light

15 source provided in the optical head 10 is collimated to parallel light and incident to an optically correcting mechanism 8 through an optical element (not shown). In the optically correcting mechanism 8, aberration is corrected with a relay lens or a liquid crystal element

20 such that an optical spot formed in, e.g., the information recording layer does not have spherical aberration. The light beam corrected by the aberration correcting mechanism 8 is incident to the objective lens 5 through an upwardly reflecting mirror 7, and

25 forms an optical spot on a predetermined information recording surface of the optical disk D. On the other hand, part of the light beam reflected on the

information recording surface is incident to a photodetector 9 through the upwardly reflecting mirror 7 again. The photodetector 9 detects a position error to a target position of the optical spot condensed on the information recording surface. There are the position errors such as a focusing position error for forming the optical spot focused on the information recording surface, a tracking position error, a slope error, and a spherical aberration error.

The information track for performing the recording and reproducing of the information is formed on the information recording surface, deviation of the position in a radial direction of the optical disk to a target track is the tracking position error. The slope error is a deviation angle between an optical axis of the light beam emitted by the objective lens 5 and a normal of the optical disk D. When the deviation angle is larger, comatic aberration occurs in the optical spot and quality of the optical spot is degraded. The spherical aberration is one which degrades the quality of the optical spot like the slope error, and spherical aberration is caused in such a manner that a wavefront condensed by the objective lens 5 shifts from a spherical surface.

In the optical disk apparatus, a positioning error detecting circuit 19 detects the above-described position errors by using the photodetector 10 and a

difference circuit 11, a compensation control circuit
20 calculates an amount of control operation corre-
sponding to each of the position errors such that the
proper optical spot is formed. The amount of control
operation is inputted to an optically correcting
mechanism control circuit 21, a focusing mechanism
control circuit 22, a finely positioning mechanism
control circuit 23, a coarsely positioning mechanism
control circuit 17, and a slope adjusting mechanism
control circuit 24, respectively. Each control circuit
drive-controls the optically correcting mechanism 8, an
objective lens positioning mechanism 6, and a coarsely
positioning mechanism 12 on the basis of the inputted
amount of control operation such that the optical spot
is properly formed at the target position. Output from
the difference circuit 11 is given to a relative
displacement calculator 13 and a speed detector 15,
calculated outputs of a reference speed generating
circuit 14 and the speed detector 15 are supplied to
the coarsely positioning mechanism control circuit 17
through an amplifier 16, and the output of the coarsely
positioning mechanism control circuit 17 drive-controls
the coarsely positioning mechanism 12.

In addition to the above-described configuration
of the driving system of the optical head 10, the
optical disk apparatus includes configurations of a
recording processing system, a reproducing processing

system, and a control system which are not shown. That is, the optical disk apparatus has a data reproducing circuit which is a circuit for the reproducing processing system connected to the optical head 10, a laser control circuit which is a circuit for the recording processing system and controls emission of a semiconductor laser diode built in the optical head 10, a CPU configuring the control portion which controls those operations, RAM and ROM which are storage regions, an interface circuit which performs data communication with an external device, and the like.

Further, FIG. 3 shows an example of a configuration of the optical disk apparatus according to the first embodiment of the invention, and FIG. 4 shows a detail configuration of an optical system of the optical head 10 in the optical disk apparatus of the invention. In these figures, the laser beam emitted from a laser light source 28 is optically adjusted with the optically correcting mechanism using the relay lens 8. A half-prism 29 is utilized in order to transmit the return light from the optical disk D to an error signal detecting system.

[First embodiment]

In the optical disk apparatus for the optical disk having one or more recording layers, the first embodiment is to provide the optical disk apparatus causing an optical head to wait at a position before an

unrecorded region by a predetermined amount after the recording or reproducing processing is completed. FIGS. 5 to 9 are views showing each example of a waiting position of the optical head in the optical disk, and FIGS. 10, 11 and 17 are flow charts for explaining waiting processing of the optical head including a layer jump of the optical disk apparatus, and the waiting method thereof.

(Principle of the waiting method of the optical head of the invention)

The reflectivity of a recorded region R is largely different from that of an unrecorded region M and the servo becomes easily unstable in the optical head waits near the boundary between the recorded region R and the unrecorded region M in the recordable optical disk having the information recording layer. Therefore, the invention enables the rapid recording processing while the operating stability is secured in such a manner that the optical head waits on the recorded region R side at a distance of, e.g., two tracks or more.

Specifically, in the medium having the low-to-high characteristics, the reflectivity of the unrecorded region is not more than 10%, and the reflectivity of the recorded region is not lower than 20%. In this case, when the servo is performed in which the optical spot is formed near the boundary between the recorded region and the unrecorded region, a component of a

reflected wave reflected by the lower reflectivity of the unrecorded region is mixed into a component reflected by the higher reflectivity of the recorded region, which affects the shift in a neutral position, at which the servo is performed, to the unrecorded region side. Thus, when the neutral position shifts to the unrecorded region side, the servo becomes a state of positive feedback in which the unrecorded region further strongly affects the servo due to the shift, and the servo becomes very unstable. In order to avoid the unstable state of the servo which remarkably appears in the low-to-high medium, the processing for avoiding the mixture of the component of the reflected wave in the unrecorded region is performed by waiting the optical head at a distance of, e.g., two tracks or more. A push-pull method or a DPD method may be used as the detecting method for obtaining servo informa-tion, though the detecting method is described later somewhat, the description is omitted here because basically it is a usual method.

As shown in FIG. 6, the optical disk for recording can be classified at least into the recorded region R where the recording has been performed and the newly recording can not be performed, the unrecorded region M where the recording has not been performed and the newly recording can be performed, and a recordable region K where the recording has been once performed

but erasing has performed and the recording can not be performed again. In the waiting method according to the invention, when the unrecorded region M does not exist but the recordable region K exists, the optical head waits before the recordable region K.

However, there is a case where the plural unrecorded regions M exist as shown in FIG. 7 or a case in which the plural recordable regions K exist as shown in FIGS. 8 and 9. In such cases, priority is shown below in deciding the waiting position.

(Priority of waiting position)

Though the priority of the waiting position is shown below by using the drawing, the priority is not limited but can be freely selected. However, the specific priority is previously decided according to a working condition, and the waiting position is decided by the waiting position determining circuit 27 in FIG. 1.

FIG. 5 shows an example of the basic optical disk D for recording, the waiting position is decided at a position, e.g., before two tracks in one unrecorded region M. The basically waiting position is shown in this case.

FIG. 6 is an example of the optical disk D for recording having plural recording layers, the waiting position is decided at a position, e.g., before two tracks in the unrecorded region M on the second

recorded region 4. When the unrecorded region M does not exist in the recording layer 3 in which the recording is finished and the unrecorded region M exists in other layers, the layer jump is performed and

5   the waiting position is decided at a position before the unrecorded region M.

FIG. 7 shows an example of the optical disk D for recording having plural recording layers. Although the unrecorded region M exists in each layer, the waiting

10   position is decided at a position, e.g., before two tracks in the unrecorded region M of the first recorded region 3 on the side of the optical head 10. The unrecorded region M in the layer on the side of the optical head 10 has the priority in principle. It is

15   also possible that the unrecorded region M in the opposite layer on the side of the optical head 10 has the priority.

FIG. 8 shows an example of the optical disk D for recording having one recording layer. The unrecorded

20   region M does not exist and the plural recordable region K exists. In this case, the waiting position is decided at a position before the recordable region K on the right, which has larger storage capacity. Although the recordable region K having the larger storage

25   capacity is selected in principle, there may be also the priority which is decided according to the position of the recordable region K.

FIG. 9 shows an example of the optical disk D for recording having plural recording layers. The unrecorded region M does not exist and the recordable region K exists in each layer. In this case, the waiting position is decided at a position before the recordable region K of the second recording layer 4, which has larger storage capacity. Although the recordable region K having the larger storage capacity is selected in principle, there may be also the priority in which the recordable region K in the layer on the side of the optical head is decided according to the position of the recordable region K.

As described above, making the unrecorded region M the priority than the recordable region K, giving the priority to the unrecorded region M of the layer on the side of the optical disk and giving the priority to the unrecorded region M closer to the recording starting position when the plural unrecorded regions M exist, or giving the priority to the recordable region K having larger storage capacity when only the plural recordable regions K exist can be set as the priority.
(Processing flow chart)

A specific example of the waiting method according to the invention, which is performed according to the above-described priority, will be described referring to the flow chart.

As described above, the optical spot is formed on

the target position to perform a series of information recording. When the recording or reproducing operation is finished, the optical head enters the waiting operation and waits until a new series of information recording or reproducing command comes to the system controller 25. A sequence of the waiting processing will be described by using the flow chart in FIGS. 10 and 11.

At first, the waiting method of the first embodiment after the information recording or reproducing is described referring to FIG. 10. If the system controller 25 determines that the information recording or the reproducing operation is finished after the information is recorded or reproduced (ST11), a recording information management portion 26 calculates the capacity of the recordable region K and unrecorded region M in the information recording layer in which the optical spots are currently formed (ST12). At the same time, the recording information management portion 26 also calculates the capacity of the recordable region and unrecorded region in the information recording layer in which the optical spots are not currently formed (ST13).

(Distinguishing method between the unrecorded region and the recordable region)

At this point, the following patterns are considered for the distinguishing method between the

unrecorded region M and the recordable region K. Where patterns 2a and 2b perceive a pattern 3 from a macroscopic viewpoint.

Pattern 1

Unrecorded region: Region where crystalline or amorphous state is uniform

Recorded region: Region where crystalline and amorphous states are mixed

Pattern 2a

Unrecorded region: Region where reflectivity is low (for example, not more than 10%)

Recorded region: Region where reflectivity is high (for example, not lower than 20%)

Pattern 2b

Unrecorded region: Region where reflectivity is high

Recorded region: Region where reflectivity is low

Pattern 3

Unrecorded region: Region where reflectivity is uniform

Recorded region: Region where regions having different reflectivities are mixed and distributed, and average reflectivity is higher or lower than the above-described region having uniform reflectivity

Pattern 4

Unrecorded region: Region where dye is uniformly distributed and reflectivity is uniform

Recorded region: Region where part of dye film is changed and regions having different reflectivities are

mixed and distributed,

Pattern 5

Unrecorded region: Region where reflection plane of optical spot is flat and uniform

Recorded region: Region where the above-described flat portion is deformed to have concavity and convexity. The above-described patterns are considered for the distinction between the unrecorded region and the recordable region. The recording information management portion 26 can distinguish between the unrecorded region M and the recordable region K by comparing a height of the reflectivity and a distribution level of the reflectivity with predetermined threshold values according to the detection results of the optical head 10.

On the basis of these results, the waiting position deciding circuit 27 determines whether or not the optical head can be moved to the unrecorded region M according to the priority (ST14). That is, the waiting position deciding circuit 27 determines whether or not the unrecorded region M to which the optical head is moved exists in the recording layer, and the waiting position deciding circuit 27 determines whether or not the recordable region K exists, when the unrecorded region M does not exist. At this point, when both the unrecorded region M and the recordable region K do not exist, the optical head waits at the

current position (ST27).

If the movable unrecorded region M or the recordable region K exists, an address to which the optical head is moved is specified (ST15). The waiting position deciding circuit 27 determines whether or not the information recording layer in which the optical spot is currently formed is the first information recording layer 3 and whether or not the unrecorded region M exists in the first information recording layer 3 (ST16). If it is determined that the unrecorded region M exists in the first information recording layer 3, the optical head performs the jump operation from the boundary region between the unrecorded region M and the recordable region K, which corresponds to the recorded address, to the track on the side of the recorded region by a predetermined number of tracks, e.g., two tracks or more. Hereinafter this operation is referred to as retracting operation. If the unrecorded region M is absent and the recordable region K is present, the optical head accesses the position before the recordable region (ST17).

The jump is finished, it is confirmed that the optical head reaches the predetermined address before two tracks from the recording end track, and then the optical spot is held to become the waiting state in a manner that performs the jump by one track in every

revolution of the optical disk D (ST18).

It is preferable that the predetermined track is decided such that the track positioning error signal detected by the push-pull method or the DPP method is not affected by the boundary region between the recorded region and the unrecorded region, and the proper value is shortly the two tracks. As shown in FIG. 2, the jumping operation for holding the track is started at the address position of the inner radius by one track, which substantially corresponds to the recording end position. As described above, when the retracting operation of at least two tracks is performed, negative effect of a change in the servo signal level, which exists in the boundary region between the recorded region R and the unrecorded region M, can be avoided, and the stably waiting operation can be realized.

Further, when a request in which the recording is performed at the position where the recording operation is finished without losing the region is given to the system controller 25, the information, which is necessary for the information recording and has been already recorded in the region before the recording start region, can be smoothly reproduced. Thereby, the recording operation can be rapidly performed without generating excessive operation before the information recording operation is started.

In the case after the recording operation has been performed into the unrecorded region M, since the recording end position becomes the boundary track, the access operation of the stop operation in step ST17 is realized in a manner that returns to the track before a first predetermined number of tracks by performing the jump (ST18).

In step ST16, when it is determined that the information recording layer in which the optical spot is currently formed is the first information recording layer 3, the unrecorded region M does not exist in the first information recording layer, and the unrecorded region M exists in the second information recording layer 4 (ST16), the layer jump is performed. That is, the access operation to the address in the predetermined second information recording layer decided by the waiting position deciding circuit 27 is performed as described below. The recording information management portion 26 detects an approximate address of the current information recording layer corresponding to the boundary region between the unrecorded region in the second information recording layer and the recorded region (ST19). At this point, in order to avoid the effect of eccentricity or the axial shift in bonding the two information recording layers, the approximate address is given as the address located on the inner radius side by about 0.1 mm (corresponding to a point

B' in FIG. 6) to the address corresponding to the
boundary region (corresponding to a point A in FIG. 6).
The access operation (ST20) is performed to the address
in the first information recording layer, and the layer

5   jump is performed to the predetermined address (point
B) in the second information recording layer after
reaching the target address (ST21). Thereafter, focus
drawing operation, various kinds of servo operation,
and track drawing operation are performed (ST22), and

10   then the reached address in the second information
recording layer is read (ST23). The access operation
is performed from the track which becomes the boundary
of the unrecorded region M in the second information
recording layer 4 to the track before a predetermined

15   number of tracks. Otherwise the access operation is
performed to the position before the recordable region
K (ST24). Then, the track drawing operation is
performed (ST25), the access is finished by the track
holding operation, and the optical head enters the

20   waiting state as shown in FIG. 6 (ST26).

In the above-described layer jump operation, if it
is determined that the information recording layer in
which the optical spot is currently formed is the
second information recording layer 4 and the unrecorded

25   region M exists in the first information recording
layer 3 (ST16), when the access is performed to the
boundary region of the first information recorded

region; the layer jump operation is also performed in the same way and the optical head enters a waiting state as shown in FIG. 7.

On the other hand, as shown in FIG. 9, if it is determined that the unrecorded region M does not exist in both the first information recording layer 3 and the second information recording layer 4 (ST14), the waiting position deciding circuit 27 compares the recordable capacities of the two information recording layers, selects the information recording layer decided as having the larger capacity as the layer in the waiting state, and accesses other layers or the boundary region of the recordable region K having the largest capacity in the current layer. In FIG. 9, the optical head is moved to the recordable region K in the second information recording layer 4.

The rotational control of the spindle motor in the access to the waiting position shown in the step ST17 or the step ST24 will be described here referring to FIG. 17. When the access to the track located at the position before the predetermined amount of tracks which is specified as the waiting position is started (ST51), the waiting position deciding circuit 27 decides whether or not the zone to which the position before the predetermined amount of tracks which is specified as the waiting position belongs is different from the zone to which the boundary region between

the recorded region R and the unrecorded region M

corresponding to the address where the recording is

completed in the step ST17, or decides whether or not

the zone to which the position before the predetermined

5   amount of tracks which is specified as the waiting

position belongs is different from the zone to which

the track located at the position before the track

which is the boundary of the unrecorded region M of the

second information recording layer by the predetermined

10   amount of tracks belongs in the step ST24 (ST52).

If the zone to which the track specified as the

waiting position belongs is the same as the zone to

which the track before the first or second predeter-

mined amount of tracks belongs, the access control such

15   as the track jump is executed without changing the

number of revolution of the spindle motor (ST53), and

the movement to the waiting position is finished

(ST54).

If the zone to which the track specified as the

20   waiting position belongs is different from the zone to

which the track before the first or second predeter-

mined amount of tracks belongs in step S52, however, it

is examined whether the tracking does not result in the

unstable state in such a manner that the optical head

25   waits at the position of the innermost track of the

zone to which the boundary region belongs (ST55). In

other words, it is decided whether the tracking becomes

stable or not by setting the innermost track of the
zone to which the boundary region belongs as the
waiting position, and it is decided by the amount of
moving tracks whether the tracking becomes stable or
5   not even if the predetermined amount of tracks is
reduced. As shown in FIG. 18, the above-described
situation occurs when the zone of the track where the
optical head will wait is different from the zone of
the recording end track. As a result of the decision,
10   even in the case of the movement to the innermost track
in the same zone, when it is decided that the amount of
moving tracks is sufficient for the waiting, the access
to the innermost track in the same zone is executed
without changing the number of revolutions of the
15   spindle motor (ST56). On the other hand, when it is
decided that the access to the innermost track in the
same zone is not sufficient for the number of returning
tracks for performing the stable tracking, the access
to the track located at the position before the
20   predetermined amount of tracks, where the optical head
will wait, is executed. At this point, usually the
number of revolutions is controlled according to the
zone, so that the control is performed at the number of
revolutions which is specified in the zone which the
25   optical head has reached. When the number of
revolutions is changed, however, the number of
revolutions must be changed again in the case that the

optical head returns to the boundary region again.
Therefore, while the number of revolutions of the
spindle motor is held at the number of revolutions of
the boundary region, the access to the track located at
the position before the predetermined amount of tracks
is executed (ST57), and the movement to the waiting
position is completed (ST54).

The waiting method of the optical head according
to the invention is performed by the above-described
procedure. When the recording processing or the
reproducing processing is finished, the optical head
waits before the unrecorded region M or the recordable
region K, which results in the secure and stable
recording processing.

(In starting the optical disk)

As shown in FIG. 11, the sequence of the waiting
method according to the first embodiment of the
invention can be also performed in starting the optical
disk D, i.e., after the optical disk D is inserted and
recognized (ST10). In step ST27, when the optical head
can not be moved, the waiting is performed at the
initial position of the optical disk. As shown in
FIGS. 5 and 8, even when the optical disk D has only
the first information recording layer 3, obeying the
procedure of the flow chart shown in FIGS. 10 and 11,
the optical head can wait at the position shown in
FIGS. 5 and 8.

(Power saving mode)

For a power saving mode, when the waiting state is maintained for a predetermined period of time or more and the system controller 25 does not receive the recording or reproducing request, the apparatus is changed to the state in which the optical spot is further moved to the recorded region side by a second predetermined number of tracks, each servo state is made to a holding state or an open-loop state, and only the focus servo is operating. The second predetermined number of tracks should be decided such that the optical spot is not formed in the boundary region by the effect of the eccentricity of the optical disk even if the track positioning servo becomes an open loop and the servo can be not controlled. When the amount of eccentricity is measured by the method such as learning, the second predetermined number of tracks is decided by the value of the amount of eccentricity. When the amount of eccentricity can not be measured, for example it is preferable that the value becomes about 0.1 mm.

Unless the retracting operation of the second predetermined number of tracks is not performed, the servo is possibly controlled into the unrecorded region, when the power saving state is released to enter the servo state again. As described above, the unrecorded region M and the recorded region R are

different in the reflectivity of the information
recording layer, it can be expected that the signal
levels for servo are largely different. As a result,
the servo state possibly becomes unstable, and a

5 countermeasure is required, in order to stably and
rapidly return from the power saving state. For the
countermeasure, the second predetermined number of
tracks is set in the above-described way to enter
the power saving state, so that the apparatus can

10 momentarily enter the stable servo state even if the
information recording or reproducing request comes to
the system controller which is in the waiting state.

Even if the retracting operation of the second
predetermined amount of tracks is performed, like the

15 control method shown in FIG. 17, the retracting
operation is performed without changing the number of
revolution of the spindle motor, so that the change in
the number of revolution of the spindle motor which
takes a great deal of time can be omitted and recovery

20 time from the power saving mode can be shortened.

The first predetermined number of tracks, which is
the avoidance from the unrecorded region M for the
first time, can be set to a relatively larger value
from start so as to be the same number as the second

25 predetermined number of tracks.

(Other)

Since the information unrecorded region is absent

in the recordable region K, the signal for the servo is
not adversely affected by the boundary between the
unrecorded region and the recorded region. However, in
order to smoothly read the necessary information for

5   the next recording operation such as the error
correcting code when the request of the recording
operation comes, it is desirable to perform the
retracting operation returning from the track, where
the final recording is finished, by the first

10   predetermined number of tracks. In this case, since
the servo state can return stably without performing
the further retracting operation by the second
predetermined number of tracks assuming the power
saving state, it is not concerned that the retracting

15   operation of the second predetermined number of tracks
is not performed.

When the remaining capacity of the recordable
region becomes a predetermined value, e.g., not more
than 32KB corresponding to 1ECC block, the waiting

20   position deciding circuit 27 determines that the
recording operation can not be performed, and the
optical head may always return to the first information
recording layer in order to prepare the reproducing
operation.

25   The unrecorded region M does not include a region
where the recording is not intentionally performed due
to the effect of a defect or the like and a region

where having storage capacity lower than a predeter-
mined capacity. When the unrecorded region M is filled
with virtual data by the request for filling the region
with the virtual data, the virtual data recorded region
5   can be treated as the unrecorded region M or the
recordable region K.

When the optical head enters the waiting state by
receiving the end of the information reproducing
operation, in the case where the end is generated by
10 the pause command and the like, the track holding
operation can be performed for the track in the end
without the access to the boundary region.

When the optical head enters the waiting state by
receiving the end of the information reproducing
15 operation, considering the possibility of resuming the
reproducing operation, the optical head waits at the
current position until the expiration of a predeter-
mined period of time. Assuming that there is no
possibility of resuming the reproducing operation after
20 the predetermined period of time, it is also possible
to newly set the operation mode in which the optical
head is moved to the unrecorded region M or the
recordable region K. By providing such operation
mode, it is possible to improve operability of the
25 reproducing processing of the recorded optical disk.

As described above, the first embodiment of the
invention is to provide the optical disk apparatus and

the waiting method thereof, in which the optical head can wait with the stable servo state in such a manner that the optical head waits before the unrecorded region M or the recordable region K, and the recording

5   processing can be rapidly resumed.

The waiting method of the invention includes at least the waiting method after the recording is continuously performed in the unrecorded region, the waiting method after the recording operation in the

10   case where the unrecorded region exists in both the two information recording layers, the waiting method after the recording is performed in the information recording layer in which the information recording has been performed at least once, and the waiting method after

15   the reproducing operation of the information.

Although the case where the optical disk has the information recording layer of one or two layers on one side has been described in the above-described first embodiment, it is possible to expect the waiting method

20   having the same effect and advantage even when the optical disk has three or more information recording layers.

Further, even if the pause command is forcedly given to the system controller during the recording or

25   reproducing of the information, by performing the retracting operation in the waiting method, the operation can be performed stably and rapidly after the

pause command is released.

[Second embodiment]

In the optical disk apparatus specified in the first embodiment of the invention, a second embodiment is to provide the optical disk apparatus and the waiting method thereof, in which the waiting position of the optical head with respect to the unrecorded region or the recordable region is set on the inner radius side of the unrecorded region or the recordable region when the optical disk has a track structure in which the recording is performed from the inner radius side to the outer radius side, and the waiting position is set on the outer radius side of the unrecorded region or the recordable region when the optical disk has a truck structure in which the recording is performed from the outer radius side to the inner radius side. FIG. 12 shows an example of the waiting position of the optical head in the optical disk apparatus according to the second embodiment of the invention.

The optical disk D shown in FIG. 12 has two information recording layers on one side, the track structure has a groove structure, the first information recording layer 3 has the track structure so as to perform the recording from the inner radius to the outer radius, and the second information recording layer 4 has the track structure so as to perform the

recording from the outer radius to the inner radius.

In the optical disk apparatus performing the recording and reproducing to the optical disk having such disk structure, since the structure is the same as that of the first embodiment, the description is omitted. The waiting method in the optical disk apparatus is also the same as the sequence of the waiting method of the first embodiment, which is shown in FIGS. 10 and 11.

With reference to the different point from the first embodiment, since the track structure of the second information recording layer 4 is a structure in which the recording can be performed from the outer radius to the inner radius, in the track jumping method in the track-holding to the target track to wait, the optical head jumps from a predetermined jump starting position toward the outer radius and waits at the position in the outer radius direction. At this point, in order to avoid the eccentricity or the axial shift in bonding the two information recording layers, the approximate address is given as the address located on the inner radius side by about 0.1 mm (corresponding to a point B' in FIG. 12) to the address corresponding to the boundary region (corresponding to a point A in FIG. 12), and the access operation, as shown in step ST20, is performed to the address within the first information recording layer 3.

After reaching the target address, similarly to
the first embodiment, the layer jump to the predeter-
mined address (point B in FIG. 12) in the second
information recording layer 4 is performed as shown
in step ST21. As shown in FIG. 12, in the second
embodiment, when the unrecorded region M exists in the
second information recording layer 4, obeying the
decision procedure shown in FIG. 10, the optical spot
waits at the position away by, e.g., two tracks or
more in the outer radius direction of the unrecorded
region M.

In this case, the rotational control method for
the spindle motor is performed by converting to not the
access to the innermost track of the zone but the
access to the outermost track according to the
structure of the recording track in the steps ST55 and
ST56 shown in FIG. 17.

As described above, in the second embodiment, it
is specified that the direction of the track jump and
the waiting position of the optical head are decided
corresponding to the recording direction in the optical
disk D.

[Third embodiment]

In the optical disk apparatus specified in the
first embodiment of the invention, a third embodiment
is to provide the optical disk apparatus and the
waiting method thereof, in which a region that should

have the priority for the waiting position when the plural unrecorded regions exist is specified in the case of a track structure having the recorded region in a groove and a land. FIG. 13 shows an example showing the waiting position of the optical head in the optical disk apparatus according to the third embodiment of the invention, FIGS. 14 and 15 are flow charts for explaining an example of the waiting method according to the third embodiment, and FIG. 16 is a block diagram showing an example of the optical disk apparatus according to the third embodiment.

The optical disk D for the third embodiment is shown in FIG. 12, and the optical disk has a truck structure having the recorded region in both the groove and the land. Further, as shown in FIG. 16, the optical disk apparatus according to the third embodiment has substantially the same structure as that according to the first embodiment of FIG. 1. However, the optical disk apparatus of the third embodiment differs from the apparatus of the first embodiment in that the apparatus of the third embodiment further has a polarity switching circuit 28 for switching between the groove and the land, and the control signal is supplied to the compensating controller 20 and the positioning error detecting circuit 19 to switch the polarity under the control of the system controller 25.

As shown in FIG. 13, in the optical disk apparatus

according to the third embodiment, usually the
recording is performed in a groove portion 102 at first
and then the recording is performed in a land portion
103. In this case, the sequence of the waiting method
5   is the flow charts shown in FIGS. 14 and 15.

The waiting method of the third embodiment will be
described in detail below referring to the flow charts
shown in FIGS. 14 and 15. It can be considered that
the groove portion and the land portion in the track
10   structure of the optical disk are different two
information recorded regions. In the sequences of
FIGS. 14 and 15, after the recording or reproducing
of the information is performed, when the system
controller 25 determines that the information recording
15   or reproducing operation is finished (ST31), the
recording information management portion 26 calculates
the capacities of the recordable region K and the
unrecorded region M of the information recording layer,
in which the optical spots are currently formed, for
20   the land portion and the groove portion, respectively
(ST32). At the same time, the recording information
management portion 26 also calculates the capacities of
the recordable region K and the unrecorded region M of
the information recording layer, in which the optical
25   spots are not currently formed, for the land portion
and the groove portion, respectively (ST33).

According to the detected result, the waiting

position deciding circuit 27 determines whether or not the optical disk can be moved to the unrecorded region M or the recordable region K (ST34), if there is the object to which the optical head can be moved, the moving address is specified (ST35). When the plural unrecorded regions M are present, the above-described waiting position can be used as the priority. When the unrecorded regions M exist in the land portion and the groove portion, respectively, for example, it is possible that the land portion has the priority, and it is also possible that the groove portion has the priority.

Further, the optical disk waits at the current position in the case where the unrecorded region M or the recordable region K, to which the optical head can be moved, does not exist, and the optical head waits at the initial position in the case of starting the optical disk (ST53).

The waiting position deciding circuit 27 determines whether or not the information recording layer in which the optical spot is currently formed is the first information recording layer 3, and determines whether or not the moving object exists in the first information recording layer (ST36). When it is determined that the waiting position is the current layer, the waiting position deciding circuit 27 determines whether it is the groove portion or the land

portion (ST37). At this point, when it is determined that the unrecorded region M exists in the groove portion, the jump operation is performed from the boundary region between the unrecorded region M and the recordable region K in the groove portion, in which the recording should be preferentially performed, to the track located by the first predetermined number of tracks on the recorded region side. In the jump operation, since sometimes the unrecorded region also exists in the land portion, when the target track in which the optical spot is currently formed is the land track (ST38), the optical head jumps to the groove track on the inner radius side with the polarity switching circuit 28 to switch the polarity of the track positioning so as to position in the groove track (ST39). Then, the jump operation is started from the boundary track in the region for the waiting to the position, e.g., before the second track or more. Alternatively, the optical head accesses the position before the recordable region K (ST40). Thereafter, the access is finished to become the waiting state (ST41). If the current status is not the groove in step ST42, the jump operation is started from the boundary track in the region for the waiting to the position, e.g., before the second track or more. Alternatively, the optical head accesses the position before the recordable region K (ST43).

On the other hand, when the unrecorded region M does not exist in the groove portion and the unrecorded region M exists only in the land portion in step ST42, the jump operation is performed from the boundary region between the unrecorded region M and the recordable region K in the land portion to the track located by the first predetermined number of tracks on the recorded region side (ST43), and the optical head enters the waiting state (ST44). In the jump operation, since the unrecorded region M does not exist in the groove region, it is not necessary to switch the polarity for the track positioning prior to the jump operation. However, when the track positioning is performed in the groove track in the starting the jump, after the optical head reaches the groove track before the position by the first predetermined number of tracks, which in converted into the groove track (ST45), the jump is performed with the polarity switching circuit 28 to the land track on the recorded region side (ST46), and the positioning to the land track is achieved (ST47).

The jump is finished, the system controller confirms that the optical head reaches the predetermined address before the recording end track by the first predetermined number of tracks. Then, the optical spot enters the waiting state in such a manner that the optical spot is held by performing the jump by

one track in every revolution of the optical disk.
At this point, in the predetermined track, it is
preferable that the predetermined track is decided so
that the track positioning error signal detected by the
push-pull method or the DPP method is not affected by
the boundary region between the recorded region R and
the unrecorded region M, and the proper value is
shortly the two tracks. As shown in FIG. 13, the
jumping operation for holding the track is started is
started at the address position of the inner radius by
one track, which substantially corresponds to the
recording end position.

As described above, when at least the two tracks
of the retracting operation is performed, negative
effect of a change in the servo signal level, which
exists in the boundary region between the recorded
region and the unrecorded region, can be avoided, and
the stably waiting operation can be realized. When a
request in which the recording is performed at the
position where the recording operation is finished
without losing the region is given to the system
controller 25, the information, which is necessary for
the information recording and has been already recorded
in the region before the recording start region, can
be smoothly reproduced and the recording operation can
be rapidly performed without generating excessive
operation before the information recording operation is

started.

On the other hand, in step ST36, when the waiting position deciding circuit 27 decides the movement from the current information recording layer to the

5   different layer in the selection of the information recording layer where the optical head waits, in the same way as the first embodiment, the layer jump which is specified by the steps ST48 to ST52 is performed, and the track positioning is temporarily performed in

10   the retractable track to obtain the address (ST52). Then, the optical head can enter the waiting state by the same procedures as those of the steps ST37 to ST47.

Sometimes the information recording layer of the optical disk D is divided into predetermined zones. In

15   this case, after performing the recording in one of the groove portion and the land portion in the divided zone, the recording in the other is started. Although, in the third embodiment, it is described that the recording is started from the groove portion, the

20   recording may be started from the land portion.

Similarly to the first embodiment, the rotational control operation for the spindle motor in the steps ST40, ST43, and ST45 is decided and performed by the steps shown in FIG. 17.

25   As described above, the third embodiment can provide the optical disk apparatus and the waiting method thereof, the remaining unrecorded region M can

be used for the recording to rapidly perform the recording with high reliability by moving the optical head to the unrecorded region M or the recordable region K in the same way as the first embodiment, even when the recorded region of the optical disk is divided into the land portion and the groove portion.

However, those skilled in the art can be realized by the various embodiments described above, those skilled in the art could easily make the various modifications of the embodiments, and apply the embodiments to various applications without any inventive ability. Accordingly, the invention covers a wide range which is not contradictory to disclosed principles and novel features, and is not limited to the above-described embodiments.

As described in detail above, according to the invention, the stable servo operation can be realized without receiving the effect of the boundary region between the unrecorded region and the recordable region, the remaining unrecorded region M can be used for the recording, and, when the recording request is given, the necessary information can be reproduced in a manner that uses the information which has been recorded by directly performing track trace, so that the optical disk apparatus and the waiting method thereof, which can rapidly start the recording operation, can be provided.